CHAPTER 3
MATERIALS AND METHODS

3.1 GENERAL

The information on the nature of wastes, its composition, physical and chemical characteristics and quantities are basic need for the planning of a Solid Waste Management System. This chapter summarizes about the methodology of various analyses, which includes municipal solid waste, characterization of MSW, mango waste, vegetable market waste, impact assessment of illegal dump site, site feasibility analysis using GIS and design of land fill.

3.2 STUDY AREA

Hosur is an industrially renowned town in Tamil Nadu and is located on the Krishnagiri-Bangalore National highway at 12°44’N latitude and 77°50’ E longitude, which is popularly known as industrial town, since major industries are situated like T.V.S, Ashok Leyland, Titan, SIPCOT-Phase I, SIPCOT-Phase II etc., It receives annual rainfall of 644 mm. The current population of the town is about 2.44 lakhs (As per 2011 census) and floating population of about 35,000/day. It is having good connectivity by road and rail. It is also an important educational, administrative and trade centre. Transportation network, influence of market and commercial activities, increased floriculture activities are due to favorable climate conditions. The Hosur new town plan extends over an area of 76.2 sq. km. The entire area is divided into six zones for the different land use. The entire
town is divided into six sanitary zones for effective management of MSW covering all 45 wards. Figure 3.1 shows the details of Hosur town map.

Figure 3.1 Hosur Town Map
3.2.1 Sources and Generation of Solid Wastes in Hosur

The Solid waste generated in Hosur Town is managed by the Public Health department of the Hosur Municipality. The data pertaining to solid waste generation, collection, existing management strategies and disposal techniques were collected and analyzed. The waste sources from residential premises, commercial and business establishment, street sweepings, institutional premises, such as schools, colleges, hotels, restaurants, hostels, hospitals, religious places, vegetable market, fruits market, fish and mutton market, community and marriage and cinema theatres, trade wastes, stable wastes construction and demolition materials were collected for analysis.

The data collections techniques included many approaches like service detail of vehicles engaged in transportation, interviews with persons involved in collection, transportation and inspectors. The realistic estimation of the quality of wastes sources and quantity of generated wastes provide us the baseline data for proper solid waste management system.

3.2.2 Prediction of Future Waste Generation.

The rate of waste generation during the 25 years is estimated by cumulative percentage increase method and is presented in the Annexure 2.

3.2.2.1 Generation rate of solid waste

MSW generation rate was determined by load count analysis and was calculated using the following expression. Table 3.1 shows the volume of vehicle and no of trips in the town.

\[
\text{Generation rate (kg / capita / day)} = \frac{\text{No of trips / day} \times \text{volume (m}^3\text{)} \times \text{density (kg / m}^3\text{)}}{\text{Population}}
\]
Table 3.1 Volume of vehicle and No. of trips in the town

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>No of vehicle in operation/day</th>
<th>No of trips/day</th>
<th>Vol of vehicle(m³)</th>
<th>Total volume(m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto rickshaw</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>64</td>
</tr>
<tr>
<td>Trucks</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>108</td>
</tr>
<tr>
<td>Tractors</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>24</td>
</tr>
</tbody>
</table>

Total volume=196

The amount of waste generated in the town was found to be 0.316 kg/capita/day, the total quantity of waste generated for the current population of 2,44,518 was 77.42 t/day, for the future population for the year 2021, it was observed that the quantity of waste generated was 111 t/day. The estimation of the projected population was done by incremental increase method.

3.2.2.2 Estimation of projected population

Projected population for the year 2021 was estimated by incremental increase method. Table 3.2 shows the projected population.

Projected population by incremental increase method is given by the following expression.

\[ p_n = p_1 + \frac{nX + n(n+1)Y}{2} \]

\[ n = p_2 - p_1 \text{ where } p_2 = \text{year of projection} \]

\[ P_1 = \text{year of latest census} \]
Table 3.2 Projected populations by Incremental increase method.

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Year</th>
<th>Population</th>
<th>Increase in population</th>
<th>Incremental increase method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1971</td>
<td>16591</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>1981</td>
<td>27129</td>
<td>10538.0</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>1991</td>
<td>42187</td>
<td>15058.0</td>
<td>4520.0</td>
</tr>
<tr>
<td>4</td>
<td>2001</td>
<td>84394</td>
<td>42207.0</td>
<td>27149.0</td>
</tr>
<tr>
<td>5</td>
<td>2011</td>
<td>244518</td>
<td>160124.0</td>
<td>117917.0</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 56981.75 \quad \bar{Y} = 49862 \]

The projected population for the year 2021 was found to be 3,51,361.

3.3 METHODOLOGY

In order to accomplish the objectives, the research work as been divided into following steps. Flow chart representing the methodology is shown in Figure 3.2.
Figure 3.2 Flow chart, describing the various steps involved in the present study

3.3.1 Solid Waste Management in Hosur Town

The Solid waste is collected in Hosur by Municipal Corporation at various points. The Solid waste Management of all 45 wards is being carried out at various levels of operation at various collection points they are, Collection from the bins and road sides by the sanitary workers including street sweeping and mopping. The waste from the dust bins and road sides is cleared by the light vehicles. The collected waste from the vehicles is transported to the dump site.

The primary collection being carried out by door to door collection through push carts and tricycles and the containers placed on streets were collected through autos, tipper lorries and dumper placers. The secondary collection of waste is being carried out through community bins; containers placed in common collection points. At present, Solid Waste of all 45 wards is handled through push carts, tipper Lorries and autos are utilized for transportation. Finally collected waste in containers is transported by the dumper placers to open disposal site at Thasaripalli near Thorepalli which is 7.5km away from the town. Figure 3.3 shows the dumpsite at Thasepalli near Thorepalli.
3.4 SAMPLE COLLECTION

The municipal solid waste samples used in this study were collected from various sampling stations at Hosur. Figure 3.4 shows the collection system in Hosur. Figure 3.5 shows the sampling stations. Groundwater samples and leachate samples were collected near and at the municipal solid waste dump site at Thorepalli near Hosur. The mango wastes are collected from mango market near TVS of Hosur and vegetable market waste were collected from Bethalapalli vegetable market near Adhiyamaan college of Engineering campus of Hosur for vermin composting.
Figure 3.4 Collection system of MSW for Hosur town
3.4.1 Segregation and storage at source

3.4.1.1 Storage at source

Storage of waste at some is the first essential step of Solid Waste Management. Every household, shop and establishment generates solid waste on day today basis. The waste should normally be stored at the source of waste generation till collected for its disposal. The types of presently used for storage equipments are containers or storage bins. The design of an efficient waste collection system requires careful consideration of the type, size and location of containers at the point generation for storage of wastes until they collected. The containers may fall under either of the following two categories Stationary containers and Hauled containers.

3.4.1.2 Segregation

A net quantity of 10 kg of sample was collected each 6 sampling points namely residential areas of Hosur like Tank Street, Shanthinagar and Bagalur HUDCO and commercial areas like MG road, Bagalur Road and Old Bangalore Road, for the physical and chemical characterization of MSW. The
collected samples were segregated into constituents like papers, plastics, wood, leather/rubber, rags, organic wastes glass, metals, debris, bones, etc. The segregated components were then weighed using a rough balance. Cone and quadrant method was adopted for obtaining a homogeneous waste for determination of moisture content. 10 kg of sample was first manually shredded well, thoroughly mixed and formed into a conical heap. The apex was flattened and divided into four quarters. One set of opposite quarters was discarded and the other set was mixed thoroughly. This was again divided into four quarters and the procedure was repeated, till sample of approximately 500gms was obtained. Figure 3.6 shows the segregation of collected solid waste.

![Figure 3.6 Segregation of collected Solid waste](image)

3.5 ANALYSIS OF PHYSICO-CHEMICAL CHARACTERISTICS OF MSW

The samples were collected from the different sampling stations in and around Hosur town for analysis of physico-chemical characteristics. During pre-monsoon and monsoon season for a period of 3 years. The samples were divided into biodegradable and non biodegradable components.
The physical composition of the municipal solid waste was determination of density of solid waste and moisture content these were determined as per the standard procedure.

Only the biodegradable components were further studied for their chemical characteristics in terms of moisture content, pH, organic matter, carbon, potassium, nitrogen, phosphorus, calorific value and C: N Ratio as per Standard Method (APHA, 1995). Solid waste should be grained and homogenized and after further drying. 500 grams of wet solid waste sample was dried is oven at 70°C to 75°C. Then the sample was placed into a mixture and grained. Then materials passed through IS sieves of 0.45 mm was used for further test.

3.5.1 Variations in MSW samples

The MSW was collected from 6 sampling stations from Hosur town during pre-monsoon and monsoon season for a period of 3 years. The variation of MSW sample was analyzed by statistical approach using multivariate analysis [MONOVA]. This technique was deployed to examine all the dependant variables simultaneous through a statistical software SPSS. Information presented in the section includes tests for each main effect (Source of waste and season) and the interaction possible in the design. It gives a general linear model between source of waste and season. The descriptive statistics is discussed in chapter IV.

3.6 VERMICOMPOSING OF MARKET WASTE

Vermicomposting of market waste was carried out in a concrete tank of dimensions 325 cm x 75 cm x 90cm, a base layer of 20cm red soil, a layer of cow dung of 15cm and market waste of 40cm with a free board of
15cm were laid. Cattle manure was procured from a dairy of AERI Campus. The cattle manure (cow dung) consisted of a mixture of facets and urine without any bedding material. The characteristics of cattle manure (cow dung) was analyzed as per standard procedure.

The market vegetable wastes are allowed for partial decomposition of 15 days in the tank, care had been taken to maintain optimum moisture of 40 percent to 70 percent regularly. The parameters like moisture content, temperature and pH were tested after 15 days of partial decomposition.

After introduction of earth worms the value of N, P, K and C were found out before and after the introduction of worms, the species of earthworms are obtained from Karnataka Compost Yard Bangalore. The earthworm used was Eiseniafoetida (red worms) of 5 kg (approximately 4000 no’s) were put into each tank for further composting. The important parameter i.e., moisture and temperature were controlled by means of spraying water over tanks in three times a day and thereby, the temperature maintained not exceeding 35°C by adorning wet gunny bags over bed and shade and moisture was maintained between 50 percent-60 percent. Under the controlled conditions the samples from the vermicompost formulations were derived at every three days and analyzed for chemical characteristics like N, P, K and C. In order to drain the excess amount of water in the tank, drain holes are provided at the sides of the tank. The cow dung and organic input in the form of vegetable matter was used as inoculants to accelerate the vermin composting process, the vegetable matter cannot act as inoculants directly, but cow dung and partially decomposed vegetable matter can be used as inoculants to accelerate the vermin-composting process. The photographic view of Vermicomposting setup is shown in the Figure 3.7 to Figure 3.15.
Table 3.3 Characteristics of cattle manure (Cow dung)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Before composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.24</td>
</tr>
<tr>
<td>Moisture Content (M/C)</td>
<td>82.34%</td>
</tr>
<tr>
<td>Total organic carbon (TOC)</td>
<td>52.25%</td>
</tr>
<tr>
<td>Total Phosphorous (TP)</td>
<td>6.91%</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>3.245%</td>
</tr>
</tbody>
</table>

The chemical characteristics of market vegetable waste before composting and after fifteen days of pre-composting were analyzed and given in Table 3.4.

Table 3.4 Chemical Characteristics of Market Vegetable Waste

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Before Composting</th>
<th>After 15 days of Pre-Composting Process in Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>82.40</td>
<td>49.5</td>
</tr>
<tr>
<td>pH</td>
<td>6.8</td>
<td>7.42</td>
</tr>
<tr>
<td>EC (dsm-1)</td>
<td>6.53</td>
<td>5.43</td>
</tr>
<tr>
<td>Total Nitrogen (percent)</td>
<td>1.6</td>
<td>1.23</td>
</tr>
<tr>
<td>Total Phosphorous (percent)</td>
<td>0.36</td>
<td>0.49</td>
</tr>
<tr>
<td>Total Potassium (percent)</td>
<td>1.66</td>
<td>1.43</td>
</tr>
<tr>
<td>Organic Carbon (percent)</td>
<td>57.6</td>
<td>24.96</td>
</tr>
<tr>
<td>C/N Ratio</td>
<td>36:1</td>
<td>20.3:1</td>
</tr>
</tbody>
</table>
Figure 3.7 The photographic view of empty tank

Figure 3.8 The photographic view of market vegetable waste
Figure 3.9 The photographic view of first layer (red soil)

Figure 3.10 The photographic view of second layer (cow dung)
Figure 3.11 The photographic view of third layer vegetable market waste

Figure 3.12 The photographic view of market vegetable waste partially decomposed
Figure 3.13  The photographic view shows of waste turning process of decomposed matter

Figure 3.14  The photographic view of earth worms
3.7 AEROBIC COMPOSTING OF MANGO WASTE

The study of aerobic composting of mango waste was taken up during the year 2004-2005. During the study period the mango market was shifted from Bangalore to Hosur near TVS temporarily and there was a proposal of establishing a permanent mango market outskirt of the Bangalore near Hosur.

During the study period the mango market covers an area of about 15 acres near TVS, Hosur. The king of tropical fruits, the mango (*Mangifera indica*) is of immense commercial importance so much so that the best of the cultivated mangoes are exported. The mango of about 1000-2000 tonnes of different varieties are brought to the market from various parts of India.

Quantity of mangoes arriving the market equal to 500 tons/day at approximate percent of mango waste generated was calculated as 10 tons/day (2 percent of the average incoming of the mangoes to the market).
Considering the mango market works 90 days in a year, the total mango waste generation in the year 2004 was 900 tones. The density of discarded mango waste was estimated as 333.33kg/m³.

During the study mango waste was collected from the mango mundi and half the quantities of mangoes were separated from their seeds and other half were retained with the seeds to dry for thirty days. An earthen pit was dug with the dimension of 50 x 40 x 30 cm to prepare the compost. Tarpaulin sheets were laid in the earth pits to avoid the percolation of water and nutrients i.e., to maintain moisture content of 40 percent as per specification. The density of mangoes was calculated after drying period of 30 days, by weight / volume method. Mango waste, cow dung and poultry waste were crushed manually. 750ml of water was added to maintain the moisture content and it was well mixed. All six samples were taken to do initial chemical characterization before dumping into waste pits. 6 samples of dried mango waste were mixed with dry poultry waste and dry cow dung with sawdust in different weight proportions or ratios as below:

1. Sample 1- 1/2 kg dry waste (without mango seed)+1/2kg poultry +1/2kg cow dung in the proportion of (1:1:1)
2. Sample 2- 1/2kg dry waste (with mango seed)+1/2kg poultry+1/2kg cow dung in the proportion of (1:1:1)
3. Sample 3 - 1kg dry waste (without mango seed)+1/2kg poultry +1/2kg cow dung in the proportion of (2:1:1)
4. Sample 4- 1kg dry waste (with mango seed ) + 1/2kg poultry+1/2kg cow dung in the proportion of (2:1:1)
5. Sample 5- 3kg dry waste (without mango seed)+1kg poultry+1kg cow dung in the proportion of (3:1:1)
6. Sample 6-3kg dry waste with mango seed) +1kg poultry+1kg cow dung in the proportion of (3:1:1).

The six different ratios of samples were dumped into six different compost pits, which were lined inside with tarpaulin sheet. The pits were covered with gunny bags after dumping the waste mixture. The materials in pits were turned once in a week to supply air for microorganisms. Every week 750ml of water was added into compost pits to maintain moisture content. After the end of 21 and 35 days, the samples were taken from each pits and analyzed for C, N, P, K and pH.

3.8 IMPACT OF MSW DUMPSITE ON GROUNDWATER QUALITY

To study the impact of MSW dumpsite on ground water quality. Groundwater samples at eight different locations were collected from a distance of 1km radius from the MSW dumping site, as per the standard method and analyzed for physical, chemical and biological parameters. The sampling and analysis were carried out using standard methods (APHA, 1995). Physico-chemical parameters namely pH, electrical conductivity, calcium, magnesium, sulphate, nitrate, chloride, total dissolved solids were determined and compared with water quality standards prescribed by WHO, ICMR and BIS. Figure 3.16 shows the sampling stations at and near the dump site.

3.8.1 Dump Site Leachate Sampling

The microbial load such as fungi, bacteria, actonomycetes and Escherichia was counted in the leachate, ground water samples in the dumping yard 100feet away from the dumping site by serial dilution method. Figure 3.16 shows the sampling stations at and near the dump site.
3.8.2 Impact of MSW Dumpsite on Soil

The various parameters of soil characteristics like pH, electric conductivity, organic carbon, phosphate, zinc, iron, potassium, calcium, magnesium, chloride and sodium are analyzed and compared with the permissible standard values for soil at 4 feet depth at the dumpsite. The standards for physico-chemical parameters of soil at various depth is shown in Table 4.17 and figure 3.16 shows the sampling station at the dumpsite.

Figure 3.16: Sampling stations near and at the dumpsite
3.9 SITE SUITABILITY ANALYSIS USING GIS & RIAM

To analyze the site suitability using GIS, IRS-P6 LISS-IV, data were used. ARC GIS 9.2 image processing software is used to identify the suitable site for solid waste disposal areas in the Hosur union. It involves preparation of thematic maps like geomorphology, land use and land cover maps, slope and drainage density map Weighted overlay analysis were applied to suggest the suitable site for solid waste disposal.

Rapid Impact Assessment Matrix (RIAM) based on the standard important assessment criteria, as well as the semi-quantitative values. RIAM is very much useful to evaluate the positive and negative impact of the project (Present/proposed) “Holistic” EIA. The identified location of the landfill is cross verified with RIAM which depict the significant positive impact to the environment by the proposed SW disposal system.